MERRIMACK RIVER BASIN

MANCHESTER, NEW HAMPSHIRE

MASSABESIC LAKE DAM
NH 00103

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

AUGUST 1978

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Merrimack River Basin
Manchester, New Hampshire
Cohas Brook

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The dam is a large concrete and stone masonry dam with earth embankments. The overall length is about 500 ft. with a maximum height of 27 ft. The dam is assessed to be in poor condition. Problems include structural cracking of an unknown origin, embankment seepage, and low spillway capacity. A test flood of 23,700 cfs inflow into the reservoir would overtop the dam by about 3.2 ft.

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

REPLY TO
ATTENTION OF:
NEDED

AUG 21 1979

Honorable Hugh J. Gallen
Governor of the State of New Hampshire
State House
Concord, New Hampshire 03301

Dear Governor Gallen:

I am forwarding to you a copy of the Massabesic Lake Dam Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Water Resources Board, the cooperating agency for the State of New Hampshire. In addition, a copy of the report has also been furnished the owner, Manchester Water Works, 281 Lincoln Street, Manchester, New Hampshire 03301.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Water Resources Board for your cooperation in carrying out this program.

Sincerely yours,

WILLIAM E. HODGSON, JR.
Colonel, Corps of Engineers
Acting Division Engineer

Incl
As stated

MASSABESIC LAKE DAM

NH 00103

MERRIMACK RIVER BASIN
MANCHESTER, NEW HAMPSHIRE

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam Massabesic Lake Dam

State Located New Hampshire

County Located Hillsborough

City or Town Manchester

Stream Cohas Brook

Date of Inspection 6/12/78 and 7/5/78

Brief Assessment

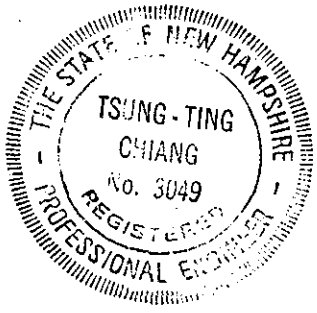
Massabesic Lake Dam is a large concrete and stone masonry dam with earth embankments. Overall length is about 500 feet and maximum height is 27 feet. The dam was constructed in 1873 and no records of design and construction are known to exist. The dam regulates the outflow of Massabesic Lake, operated as water supply by the City of Manchester. The dam is assessed to be in the high hazard classification.

Massabesic Lake Dam is assessed to be in overall poor condition. Problems include structural cracking of an unknown orgin, embankment seepage, and low spillway capacity.

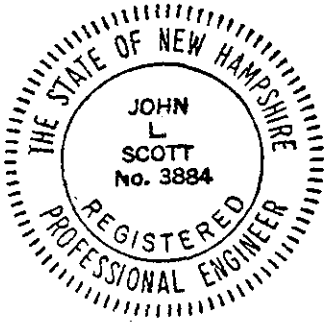
A test flood (equal to the probable maximum flood) of 23,700 cfs inflow into the reservoir would overtop the dam by about 3.2 feet. Spillway capacity is about 24% of the test flood outflow. If the existing flashboards were replaced with properly designed flashboards, the spillway capacity would increase to about 37% of the test flood outflow, and the overtopping height would drop to about 1.7 feet.

Recommmendations include obtaining professional advice on (1) the cause of the spillway structural cracking, (2) decreasing flood vulnerability, and (3) repairing the seepages uncovered. Action is also recommended on other less serious matters. The owner should carry out the recommendations and remedial measures within 12 months after receipt of this Phase I Report.

WHITMAN & HOWARD, INC.



T. T. Chiang, Ph.D., P.E.



John L. Scott, P.E.

This Phase I Inspection Report on Massabesic Lake Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

CHARLES G. TIERSCH, Chairman
Chief, Foundation and Materials Branch
Engineering Division

FRED J. RAVENS, Jr., Member
Chief, Design Branch
Engineering Division

SAUL COOPER, Member
Chief, Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the spillway test flood is based on the estimated "Probably Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a high inadeqaute condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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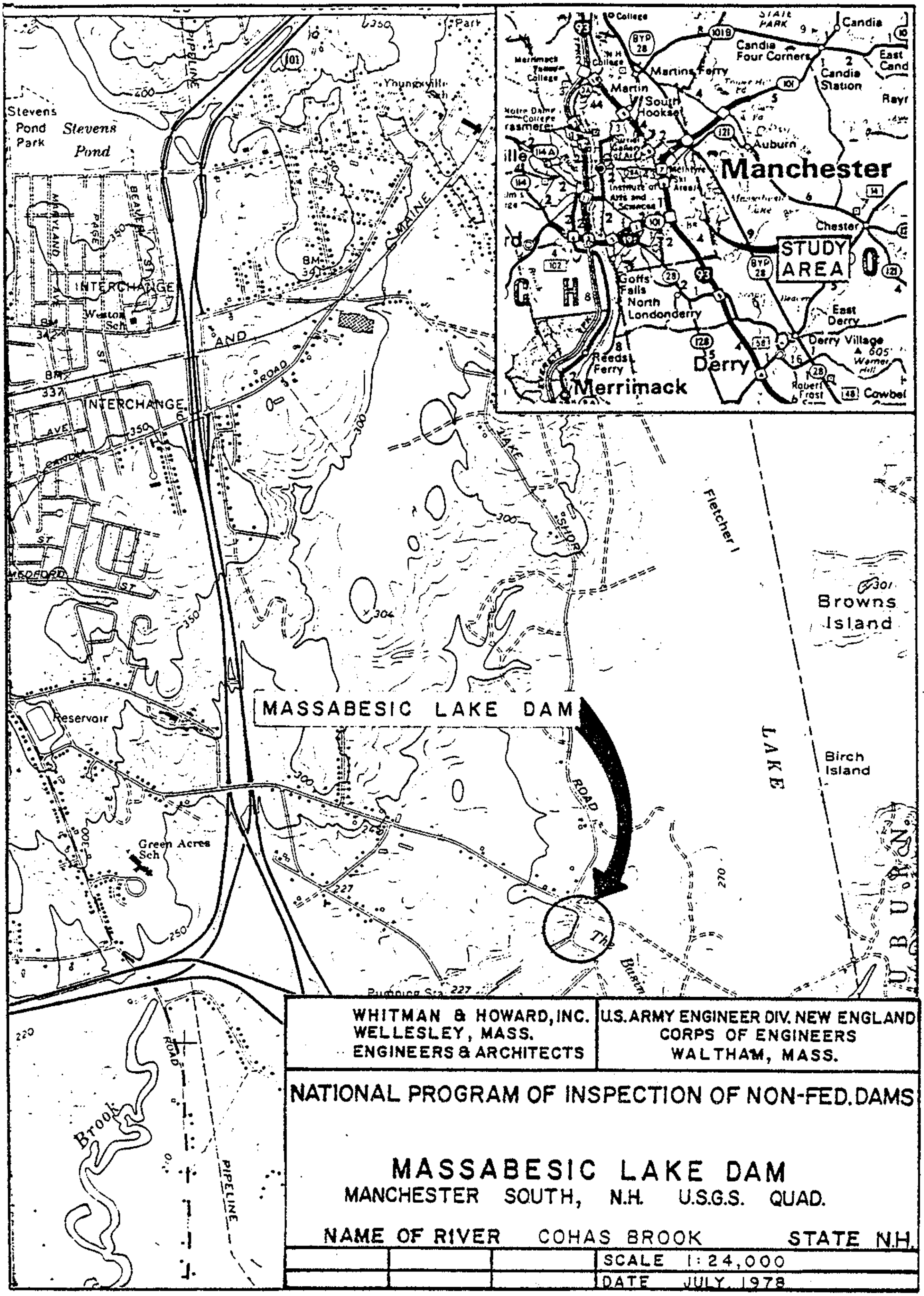
MASSABESIC LAKE DAM

Manchester, N.H.

Approx. Scale 1" = 280'



WHITMAN & HOWARD, INC.
WELLESLEY, MASS.
ENGINEERS & ARCHITECTS

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

MASSABESIC LAKE DAM

MANCHESTER SOUTH, N.H. U.S.G.S. QUAD.

NAME OF RIVER COHAS BROOK STATE N.H.

SCALE 1:24,000

DATE JULY 1978

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
MASSABESIC LAKE DAM ID# N.H. 00103

SECTION 1
PROJECT INFORMATION

1.1 General

a. Authority

Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Whitman & Howard, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of New Hampshire. Authorization and notice to proceed was issued to Whitman & Howard, Inc. under a letter of May 1, 1978 from Ralph T. Garver, Colonel, Corps of Engineers. Contract No. DACW33-78-C-0313 has been assigned by the Corps of Engineers for this work.

b. Purpose

(1) Perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.

(2) Encourage and prepare the States to quickly initiate effective dam safety programs for non-Federal dams.

(3) To update, verify and complete the National Inventory of Dams.

1.2 Description of Project:

a. Location

Massabesic Lake Dam is located in Manchester, New Hampshire. The dam is 2,000 feet southwest of the natural outlet of the lake. The discharge from the dam flows into Cohas Brook, a tributary of the Merrimack River.

b. Description of Dam

The Massabesic Lake Dam is a large concrete and stone masonry dam with earth embankments. The permanent spillway crest is at elevation 248.93 ft. msl, and 18" non-failing flashboards are employed across the 100' wide spillway. A bridge across the crest carries light through traffic. A 30" diameter sluice pipe is located on the left side of the spillway through the base of the dam. A gate house leading to the water supply canal is located just beyond the end of the left embankment. It is not known if there are core walls in the earth abutments.

There is a low concrete weir structure known as The Cofferdam located at the original natural outlet of the lake. It was probably built at the same time as the dam to maintain the lake level and regulate flow during construction. It consists of a central sluiceway and low concrete walls on each side extending to high ground. The sluiceway has slots for stop logs. The majority of the structure stays submerged, as the top of the concrete is about level with the dam crest, 18" below the top of flashboards. The structure appears sturdy and serviceable and might be useable to maintain the lake level in the event draining the main dam for inspection or repairs became necessary.

c. Size Classification

Although the height of the dam is less than forty feet, the relatively large volume of impounded water places this project at the upper end of the "Intermediate" size classification.

d. Hazard Classification

Cohas Brook flows westerly from the dam, passing beneath and flowing beside I-93 at the 101/193 interchange about 3/4 mile downstream. From there it enters a flat area about 1 mile long between S. Mammoth Road and Rte. 28. Then the stream valley narrows and steepens, draining into Pine Island Pond and joining the Merrimack in a short steep drop under Rte. 3A at Goffs Falls. Sudden failure would cause much property damage and some loss of life, particularly in the Pine Island Pond area. I-93 could be inundated. In addition to the flood hazard, the water supply for the City of Manchester would be severely reduced. For these reasons, this dam is placed in the "High" hazard classification.

e. Ownership

The dam was built and is owned by the Manchester Water Works, the public water utility for the City of Manchester. The city uses Massabesic Lake as a source of drinking water.

f. Operator - Ethan Howard, Maintenance Foreman
Manchester Water Works
281 Lincoln Street
Manchester, NH 03103
603/668-3830

g. Purpose of Dam

The dam was built to control the level of the lake and to direct water to a pump station/ hydroelectric facility on Cohas Avenue. However a new water treatment plant has been constructed and the water supply function of the plant is now used only for "stand-by" service. The hydroelectric facility remains fully active.

h. Design and Construction History

In 1872, the first Water Board of the City of Manchester designated Massabesic Lake as the best source of water supply for the City, and proceeded to acquire land around the lake and rights to the water. A year later, in 1873, the present dam was constructed. The crest was designed to be 2 feet below the normal "full lake" level and flashboards were used to maintain the surface at the best practical elevation. At the same time, the pumping station on Cohas Avenue was built, which also housed the hydroelectric facility to supply some of the power for the pumps. The canal and conduits were constructed to feed water from the dam to the station.

Over the years, there have been at least four changes in the crest design and flashboard arrangements. A particularly fortunate revision was made to increase the spillway capacity in 1931. Had it not been done, the dam would probably have suffered considerable damage in the flood of March 1936. The last major change came in 1945, when the crest was rebuilt into an ogee cross section and the bridge was raised one foot. These changes made for an increase in spillway capacity.

In 1974, a new water treatment plant was constructed on another part of the lake, which relegated the water supply intake system at the dam to standby status, although the hydroelectric facility is still operating in its original capacity.

i. Normal Operating Procedure

All water not taken in at the Water Treatment Plant is allowed to flow over the spillway. During times of abundant flow, the hydroelectric plant is operated.

1.3 Pertinent Data

a. Drainage Area

The drainage area at the dam is 47 sq. mi., and is considered as "flat" terrain hydrologically. Tower Hill Pond Dam is located upstream.

b. Discharge at Damsite

(1) Maximum known flood - 2,230 cfs, Mar., 1936

(2) Spillway capacity at maximum pool elevation
Without permanent flashboards - 4,640 cfs
With permanent flashboards - 2,880 cfs

(3) Discharge conduit - 30" diam., invert 226.8 capacity at maximum pool elev. - 180 cfs

(4) Total capacity of spillway and conduit - 4,820 cfs

c. Elevation (ft. above MSL)

(1) Top Dam - 254.52

(2) Maximum pool-design surcharge - 253.1 (bottom stringers of bridge)

(3) Full flood control pool - N/A

(4) Recreation pool - N/A

(5) Spillway crest - 248.93

(6) Invert of discharge conduit - 226.8

(7) Streambed at centerline of dam - Approx. 225

(8) Maximum Tailwater - Unknown

d. Reservoir

(1) Length of maximum pool - Approx. 25,200 ft.

(2) Length of normal pool - Approx. 25,000 ft. (odd shape)

(3) Length of flood contol pool - N/A

e. Storage (acre - ft.)

(1) Spillway crest - 39,500

(2) Flood control pool - N/A

(3) Design surcharge - 42,000

(4) Top of Dam - 44,450

f. Reservoir Surface (acres)

(1) Top Dam - Est. 3,000

(2) Maximum pool - Est. 2,900

(3) Flood control pool - N/A

(4) Recreation pool - N/A

(5) Spillway crest - 2,630

g. Dam

(1) Type - Concrete and stone masonry with earth embankments and long canal with earth embankments.

(2) Length - 500 ft. (odd shape)

(3) Height - 27 ft.

(4) Top width - 12 ft.

(5) Side Slopes - Upstream vertical walls; downstream 1.5:1 approx.

(6) Zoning - Unknown

(7) Impervious core - Unknown

(8) Cutoff - Unknown

(9) Grout curtain - Unknown

h. Diversion Tunnel

There are two separate outlet systems. One is a 30" pipe located at the base of the concrete dam. It is about 40 feet long and the flow is controlled by a 36" x 60" sluice gate. The gate is controlled with a hand crank operator atop the dam and has not been operated in recent years. The submerged channel leading to the sluice gate is odd shaped and constructed of stone masonry.

The other outlet system diverts water to the pumping station and hydroelectric facility. The system consists of a 36 inch intake pipe controlled from a gatehouse, a 1470 foot long canal, a second gatehouse at the far end of the canal, and a large conduit which leads to the hydroelectric and pumping station on Cohas Avenue. The discharge from the hydro-electric plant returns to Cohas Brook below the dam. The first gate is left open continuously and the second gate is operable.

i. Spillway

(1) Type - Concrete ogee

(2) Length of weir - 100 ft.

(3) Crest elevation - 248.93

(4) Gates - 18" permanent (non-failing) flashboards

(5) Upstream channel - lakeshore

(6) Downstream channel - Cohas Brook streambed

(7) General - Roadway over crest supported on 4 piers

SECTION 2 - ENGINEERING DATA

2.1 Design

There is no information available concerning the design of the dam and appurtenant structures. A few plans show repairs that have been made, but they do not show the original work.

2.2 Construction

No construction records exist from either the original construction or later additions.

2.3 Operation

A few spotty lake level records are available. However, the operation of the dam is simple and no records have been kept. Some flood records were kept.

2.4 Evaluation

a. Availability - Poor. Few data exist.

b. Adequacy - N/A. Evaluation must be based heavily upon visual observation.

c. Validity - N/A.

SECTION 3 - VISUAL INSPECTION

3.1 Findings

a. General

The findings of the inspection are presented in the visual inspection checklist.

b. Dam

The face of the spillway has several vertical cracks that run nearly the entire height of the dam. These cracks were repaired with an epoxy sealant in 1975. Approximately 50 weep holes were observed in the spillway face; those that could be readily reached were from 2' to 5' deep and fairly clear. The flashboards were securely bolted to the sides of the piers and it is unlikely that they would fail from a head less than the available freeboard.

A 12' v.c. pipe was discharging water at a point on the downstream slope near the northeast abutment. The origin was not found. The water being discharged was clear. There is a large seepage area at the downstream toe near the southwest end of the dam. The stone masonry joints on the upstream face on the southwest end of the dam have missing mortar.

c. Appurtenant Structures

The Cofferdam appears in serviceable condition.

Seepage is taking place through and/or under the canal embankments near its downstream end (farthest from the dam).

d. Reservoir Area

All land around Massabesic Lake is owned by the Water Works and recreation is prohibited.

e. Downstream Channel

The channel downstream of the spillway is covered with sand, gravel, and boulders. There are trees and brush growing in the channel.

3.2 Evaluation

The seepage taking place at the toe of the embankment near the southwest end of the dam could lead to long-term instability if not remedied. The seepage from both sides of the downstream end of the canal downstream of the gated outlet could lead to long-term instability of the embankments on the sides of the canal. The footpath from the toe to the crest of the southwest embankment next to the spillway could lead to serious long-term erosion if it is not remedied. Because of the high water on the upstream face, that part of the dam could not be inspected. The portion of the face above the water showed that repair of the stone masonry points was needed.

The reason for the vertical cracks in the spillway is unclear and has not been fully investigated. Although it is reported that these cracks did not leak, and that the epoxy sealant has bonded securely, it would be prudent to find the reason for their development.

Massabesic Lake Dam is assessed to be in overall poor condition. See Section 7.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures

In periods of ample water, the hydroelectric plant is operated. Otherwise all flow that is not drawn off at the water treatment plant goes over the spillway.

4.2 Maintenance

The dam has been repaired as needed, and regular clean-up operations have been performed conscientiously. However, trees have been allowed to grow on embankments.

4.3 Maintenance of Operating Facilities

The sluice gate at the dam is not operated. Its condition is unknown. The flashboards are non-failing.

4.4 Warning System

There is no formal warning system at the dam.

4.5 Evaluation

The flashboards should be converted to a failing type. The sluice gate should be operated regularly.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design Data

No data exists on the original design of the dam. Criteria for spillway capacity are not known.

The 1945 spillway revision appears to have been designed to pass the 1936 flood peak flow of 2,230 cfs with a small amount of freeboard to spare, although this is not certain.

b. Experience Data

The flood of March, 1936 very nearly overtopped the dam, rising to .1 ft. above the bottom of the bridge stringers (then lower than now).

There have been numerous changes in spillway crest and flashboard configurations. Most of the changes appear to have been made with maintenance and operation practicality in mind rather than hydraulic considerations.

c. Visual Observations

The flashboards in their present state appear to be permanent (non-failing) in nature. This reduces the spillway capacity and increases the overtopping potential.

The cofferdam at the former natural lake outlet appears sturdy and serviceable. The central sluiceway invert is about 5' lower than the spillway crest.

d. Overtopping Potential

Reference is made to Appendix D for the hydrologic computations performed as a part of this report.

The probable maximum flood (PMF) for this dam is computed to be about 23,700 cfs inflow

into Massabesic Lake. The probable maximum flood is defined as the largest flood that can reasonably be expected to occur on a given stream at a selected point, or the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

For dams of the size and hazard classifications of Massabesic Lake Dam, the "test flood" is generally chosen as the full PMF. The test flood is that flood used to evaluate the hydraulic adequacy of a project. The test flood for Massabesic Lake Dam is selected at the full PMF.

During the PMF, the peak outflow at the dam would be about 12,600 cfs, the reduction from the peak inflow of 23,700 cfs being accounted for by the considerable surcharge storage "cushioning" effect of the lake. In its present state, the spillway capacity is 3,060 cfs, or about 24% of the test flood peak outflow. At the moment of peak outflow, the dam would be overtopped by about 3.2 feet. Whether the dam could withstand this degree of overtopping cannot be determined.

If the existing permanent flashboards were replaced with properly designed flashboards, the spillway capacity would increase to 4,600 cfs (about 37% of test flood), and overtopping height would decrease to about 1.7 feet.

SECTION 6 - STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

The upstream face of the earthen embankment sections is a vertical masonry wall.

A paved roadway crosses on the crest of the dam.

The downstream toe of the northeast embankment section is covered with trees and brush. The downstream slope of the southwest embankment section is covered with grass. Trees and brush are growing downstream of the toe of both the northeast and southwest embankment section.

There is a large seepage area at the downstream toe near the southwest end of the dam.

Vertical cracks on the spillway face have developed in recent years. The Cofferdam appears in sound and serviceable condition.

b. Design and Construction Data

No data available. Upstream configuration of spillway structure and embankment construction are unknown.

c. Operating Records

No useful data is available. The age of the dam, and the fact that it has survived several severe floods, is a favorable indicator of basic stability.

d. Post-construction Changes

Several changes have occured to the spillway crest. Plans of the most recent change (1945) are available. See design and construction history in Section 1.

e. Seismic Stability

This dam is in Seismic Zone 2 and hence does not have to be evaluated for seismic stability in accordance with the OEC Recommended Guidelines.

SECTION 7 - ASSESSMENTS, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition

The visual inspection indicates that Massabesic Dam is in poor condition. The major concerns regarding the longterm stability of the dam with respect to soils and geology are the seepage at the downstream toe of the embankment near the southwest end of the dam, the seepage from both sides of the downstream end of the canal through which water from the gated outlet discharges, and the presence of large trees and brush on the downstream slope of the embankment sections of the dam.

The major structural concern is the development of vertical cracks in the spillway.

The major hydraulic concern is the low spillway capacity, aggravated by non-failing flashboards.

In addition, a number of operation and maintenance procedures should be followed as outlined in 7.3.b, below.

b. Adequacy of Information

The information available is such that the assessment of the safety of the dam must be based on the visual inspection. Because of the importance of the visual inspection it is necessary that the upstream face be inspected.

c. Urgency

The recommendations and remedial measures mentioned below should be implemented within one year after receipt of this Phase I Report.

d. Necessity for Additional Inspection

Due to the lack of design and construction information, the age of the structure, and

the problems noted, it is advised that measures be taken to inspect and survey (and possibly repair) the upstream face, gates, and channel bottom.

If it is determined that drawdown is necessary, this might be possible to carry out without draining the main body of the lake by regulating the Cofferdam.

This dam should undergo a thorough inspection by a competent engineer once a year, in addition to regular observation visits by maintenance personnel.

7.2 Recommendations

The owner should retain a competent engineer with special experience in structural problems of dams to investigate the cause or causes of the vertical cracking in the spillway, and to implement a remedy if necessary.

The owner should retain a competent engineer to advise on the best method of decreasing the dam's vulnerability to damage by large floods (e.g., spillway enlargement, emergency spillway construction, armoring overtopping, etc.).

The owner should retain a competent engineer to advise on repairing the seepages at the downstream toe of the southwest end of the dam and from both sides of the canal through which water from the gated outlet discharges.

The owner should also cut the trees and brush on the downstream slope of the embankment sections of the dam and for a distance of 100 feet downstream of the dam, and should engage a competent engineer to supervise the removal of the tree roots and replacement with a proper backfill.

7.3 Remedial Measures

a. Alternatives - N/A

b. Operating and Maintenance Procedures

(1) The owner should take necessary action to prevent further erosion of the footpath from the toe to the crest of the southwest embankment section adjacent to the spillway.

(2) The owner should take necessary action to repair and eliminate further erosion caused by water flowing from the pipe that discharges on the downstream slope near the northeast end of the dam.

(3) The downstream slope of the embankment sections and an area 100 feet downstream of the dam should be maintained free of brush and trees.

(4) The flashboard system should be replaced or modified so as to fail at a head safely under the available freeboard.

(5) The sluice gate for the pipe through the dam should be reactivated and maintained as should all gates (and other moving parts) for the canal operation.

(6) Round the clock surveillance should be provided by the Owner during periods of unusually high flows caused by heavy precipitation, rapid snowmelt, or other reasons. The Owner should develop a formal warning system with local officials for alerting downstream residents in case of emergency.

MASSABESIC LAKE DAM

APPENDICES

A Visual Inspection Checklist - 9 pp.

B Engineering Data with Index

C Inspection Photographs with Index - 12 photos

D Hydrologic Computations

E Information as Contained in the National Inventory of Dams

APPENDIX A

VISUAL INSPECTION CHECK LIST
PARTY ORGANIZATION

PROJECT Massabesic Lake Dam

DATE June 12, 1978*

TIME 9:00 AM start

WEATHER sunny - hot

W.S. ELEV. 250.5 U.S. not measured DN.S.
(about 1" over flashboards)

PARTY:

1. T.T. Chiang, W&H
2. J. Scott, W&H
3.
4.
5.
6.
7.
8.
9.
10.

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.	All features	Chiang & Scott	
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
.0.			

Second inspection - see next page.

heck list combines observations of both inspections

VISUAL INSPECTION CHECK LIST
PARTY ORGANIZATION

PROJECT Massabesic Lake Dam

DATE July 5, 1978*

TIME 9:30 AM start

WEATHER clear, cool

W.S. ELEV. 250.0 (about 5" below flashboards) U.S. not measured DN.S.

PARTY:

1. J. Scott, W&H
2. R. Hirschfeld, Geotechnical Engineers, Inc.
3.
4.
5.
6.
7.
8.
9.
10.

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.	All features	Scott & Hirschfeld	
2.			
3.			
4.			
5.			
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9.			
10.			

Second inspection - see previous page for details of first inspection.

PERIODIC INSPECTION CHECK LIST

OJECT Massabesic Lake Dam DATE 6/12/78 & 7/5/78

OJECT FEATURE Main concrete section NAME Entire party

SCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
M EMBANKMENT	
Crest Elevation	
Current Pool Elevation	250.5 on 6/12; 250.0 on 7/5
Maximum Impoundment to Date	4.27' over crest - 1936 flood
Surface Cracks	Five vertical cracks in spillway face - repaired with epoxy in '75
Pavement Condition	Some cracking and unevenness of pavement next to south end of service bridge
Movement or Settlement of Crest	None
Lateral Movement	None
Vertical Alignment	OK
Horizontal Alignment	OK
Condition at Abutment and at Concrete Structures	Many stone masonry joints need repointing - some quite bad, especially at normal water line on left upstream face
Indication of Movement of Structural Items on Slopes	None
Trespassing on Slopes	Footpath from road to toe adjacent to south abutment wall. Some junk thrown in discharge channels
Sloughing or Erosion of Slopes or Abutments	None
Rock Slope Protection-Riprap Failures	Vertical stone walls around upstream area need repointing
Unusual Movement or Cracking at or near Toes	None
Unusual Embankment or Downstream Seepage	Seepage area at downstream toe of embankment near south end of dam
Piping or Boils	None
Foundation Drainage Features	None
Toe Drains	Outfall of 15" conc. pipe found next to base of north abutment - origin unknown
Instrumentation System	None

PERIODIC INSPECTION CHECK LIST

PROJECT Massabesic Lake Dam DATE 6/12/78 & 7/5/78

PROJECT FEATURE Embankments on both sides of main concrete section NAME Entire party

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
DIKE EMBANKMENT	
Crest Elevation	General Notes:
Current Pool Elevation	Downstream face of both embankments has extensive tree and shrub growth. Slope quite steep.
Maximum Impoundment to Date	
Surface Cracks	
Pavement Condition	
Movement or Settlement of Crest	
Lateral Movement	
Vertical Alignment	
Horizontal Alignment	
Condition at Abutment and at Concrete Structures	
Indications of Movement of Structural Items on Slopes	
Trespassing on Slopes	
Sloughing or Erosion of Slopes or Abutments	
Rock Slope Protection-Riprap Failures	
Unusual Movement or Cracking at or near Toes	
Unusual Embankment or Downstream Seepage	
Piping or Boils	
Foundation Drainage Features	
Toe Drains	
Instrumentation System	

PERIODIC INSPECTION CHECK LIST

PROJECT Massabesic Lake Dam DATE 6/12/78 & 7/5/78

PROJECT FEATURE _____ NAME All party

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS-INTAKE CHANNEL AND INTAKE STRUCTURE	
a. Approach Channel	None as such
Slope Conditions	
Bottom Conditions	
Rock Slides or Falls	
Log Boom	
Debris	
Condition of Concrete Lining	
Drains or Weep Holes	
b. Intake Structure	30" sluice thru dam has gate in unknown condition (maintenance foreman declined to operate).
Condition of Concrete	
Stop Logs and Slots	Gate house leading into canal: gates always open - not exercised in a long time

PERIODIC INSPECTION CHECK LIST

PROJECT Massabesic Lake Dam DATE 6/12/78 & 7/5/78

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS-TRANSITION AND CONDUIT	
General Condition of Concrete	Apron eroded slightly - good condition
Rust or Staining on Concrete	
Spalling	None
Erosion or Cavitation	Apron leads directly to natural channel. Considerable amount of trash has been thrown into channel.
Cracking	
Alignment of Monoliths	
Alignments of Joints	
Numbering of Monoliths	

PERIODIC INSPECTION CHECK LIST

ROJECT Massabesic Lake Dam DATE 6/12/78 & 7/5/78

ROJECT FEATURE _____ NAME _____

ISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
UTLET WORKS-OUTLET STRUCTURE AND OUTLET CHANNEL	"Outlet channel" - canal leading to gatehouse at far end. Thence a conduit to pump and hydroelectric plant on Cohas Ave
General Condition of Concrete	
Rust or Staining	Gates in far gatehouse operated regularly while hydro plant is working (did not observe operation)
Spalling	
Erosion or Cavitation	
Visible Reinforcing	
Any Seepage or Efflorescence	
Condition at Joints	
Drain Holes	
Channel	
Loose Rock or Trees Overhanging Channel	None
Condition of Discharge Channel	Generally good. Some seepage is taking place through the canal embankments at the far (south) end, on both sides

PERIODIC INS ECTION CHECK LIST

PROJECT Massabesic Lake Dam DATE 6/12/78 & 7/5/78

PROJECT FEATURE Crest & Spillway Face NAME

DISCIPLINE NAME

AREA EVALUATED	CONDITION
OUTLET WORKS-SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	No real "approach channel"
General Condition	N/A
Loose Rock Overhanging Channel	N/A
Trees Overhanging Channel	N/A
Floor of Approach Channel	Could not inspect
b. Weir and Training Walls	
General Condition of Concrete	Normal erosion - good, considering age.*
Rust or Staining	None
Spalling	Very little
Any Visible Reinforcing	No (plain concrete over stone masonry)
Any Seepage or Efflorescence	None
Drain Holes	Many. Generally clear, 2'-5' deep
c. Discharge Channel	Spillway discharges directly to natural channel, which is considerably overgrown with trees and brush.
General Condition	
Loose Rock Overhanging Channel	
Trees Overhanging Channel	
Floor of Channel	
Other Obstructions	

*Five vertical cracks - see Main Concrete Section checklist

PERIODIC INSPECTION CHECK LIST

ROJECT Massabesic Lake Dam DATE 6/12/78 and 7/5/78

ROJECT FEATURE Bridge over crest NAME

SCIPLINE NAME

AREA EVALUATED	CONDITION
TLET WORKS-SERVICE BRIDGE	
Super Structure	Bridge has wood plank wearing surface.
Bearings	Bridge is in good overall condition
Anchor Bolts	Used for light thru traffic - est. 50 cars/day
Bridge Seat	
Longitudinal Memebers	
Under Side of Deck	
Secondary Bracing	
Deck	
Drainage System	
Railings	
Expansion Joints	
Paint	
Abutment & Piers	
General Condition of Concrete	
Alignment of Abutment	
Approach to Bridge	
Condition of Seat & Backwall	

APPENDIX B

MASSABESIC LAKE DAM

INDEX TO ENGINEERING DATA

3 Plates - Plan, plus 2 sections

Letter from Whitman & Howard, Inc. about general crack repair, 6/4/75

Letter from Manchester Water Works to N.H. Water Resources Board about leakage, 3/6/75

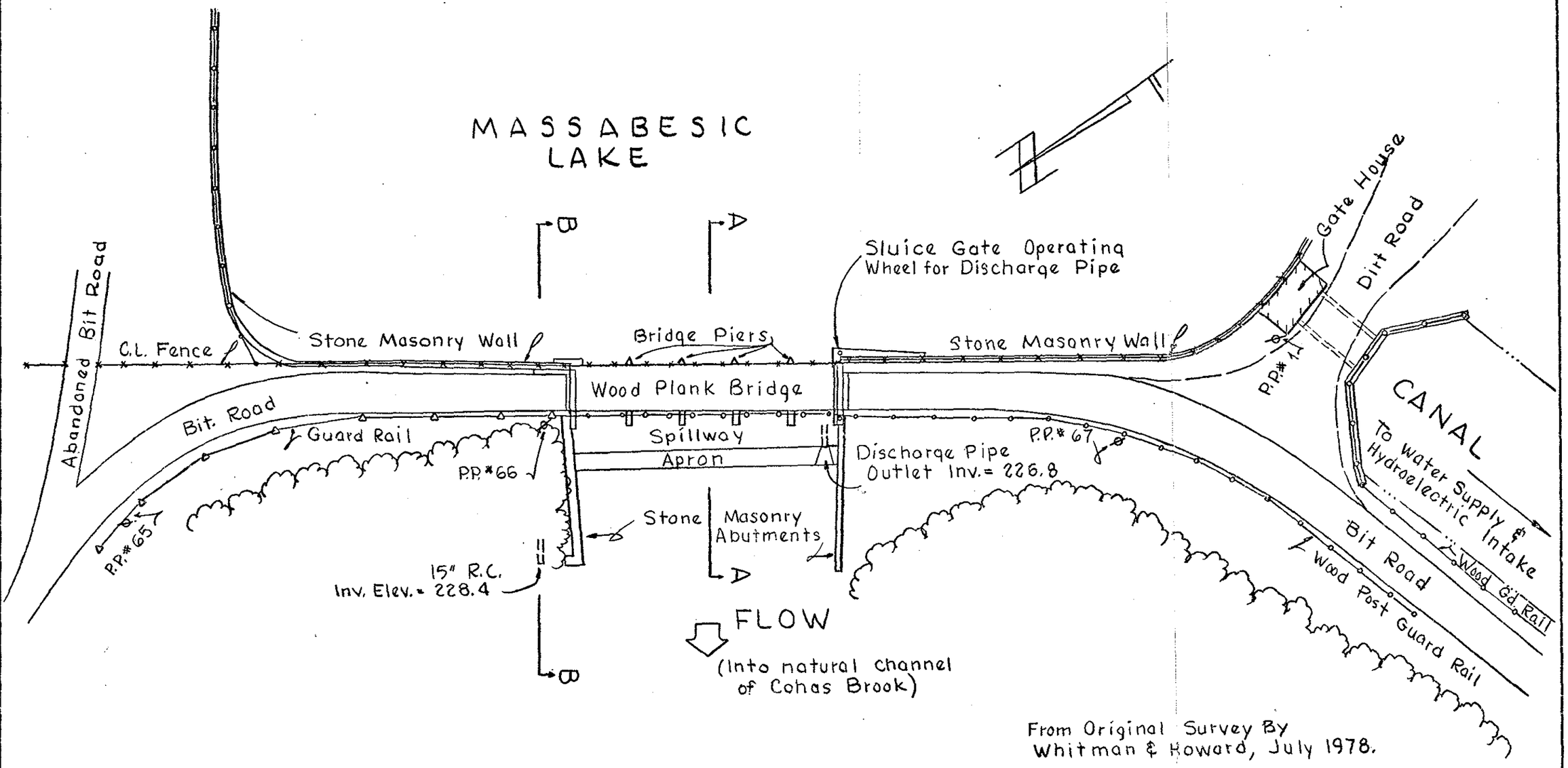
Letter from N.H. Water Resources Board to Manchester Water works, 2/14/75

N.H. Water Resources Board Dam Safety Inspection Report Form, 7/26/74

Chronology of spillway changes 1873-1945

Engineer's design notes on spillway improvements of 1945

Lake levels in 1936 (showing flood of March 1936)



PLAN

Scale : 1"= 40'

WHITMAN & HOWARD INC. ENGINEERS AND ARCHITECTS WELLESLEY, MASS.	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

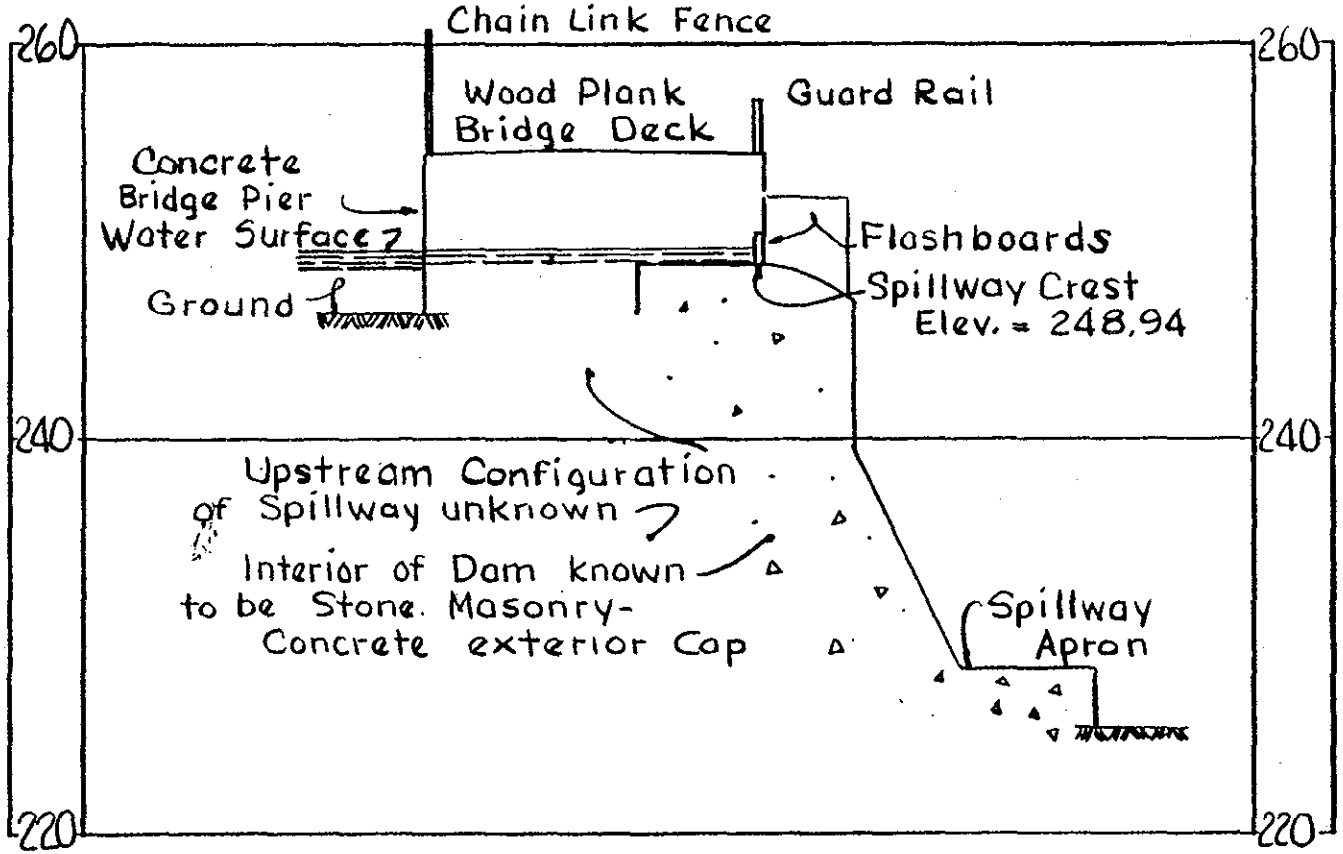
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

MASSABESIC LAKE DAM

COHAS BROOK — NEW HAMPSHIRE

SCALE 1"= 40'

DATE AUGUST, 1978



SECTION A
TYPICAL SPILLWAY SECTION
1" = 10'

From original survey by
Whitman & Howard, July 1978.

WHITMAN & HOWARD INC. ENGINEERS AND ARCHITECTS WELLESLEY, MASS.	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

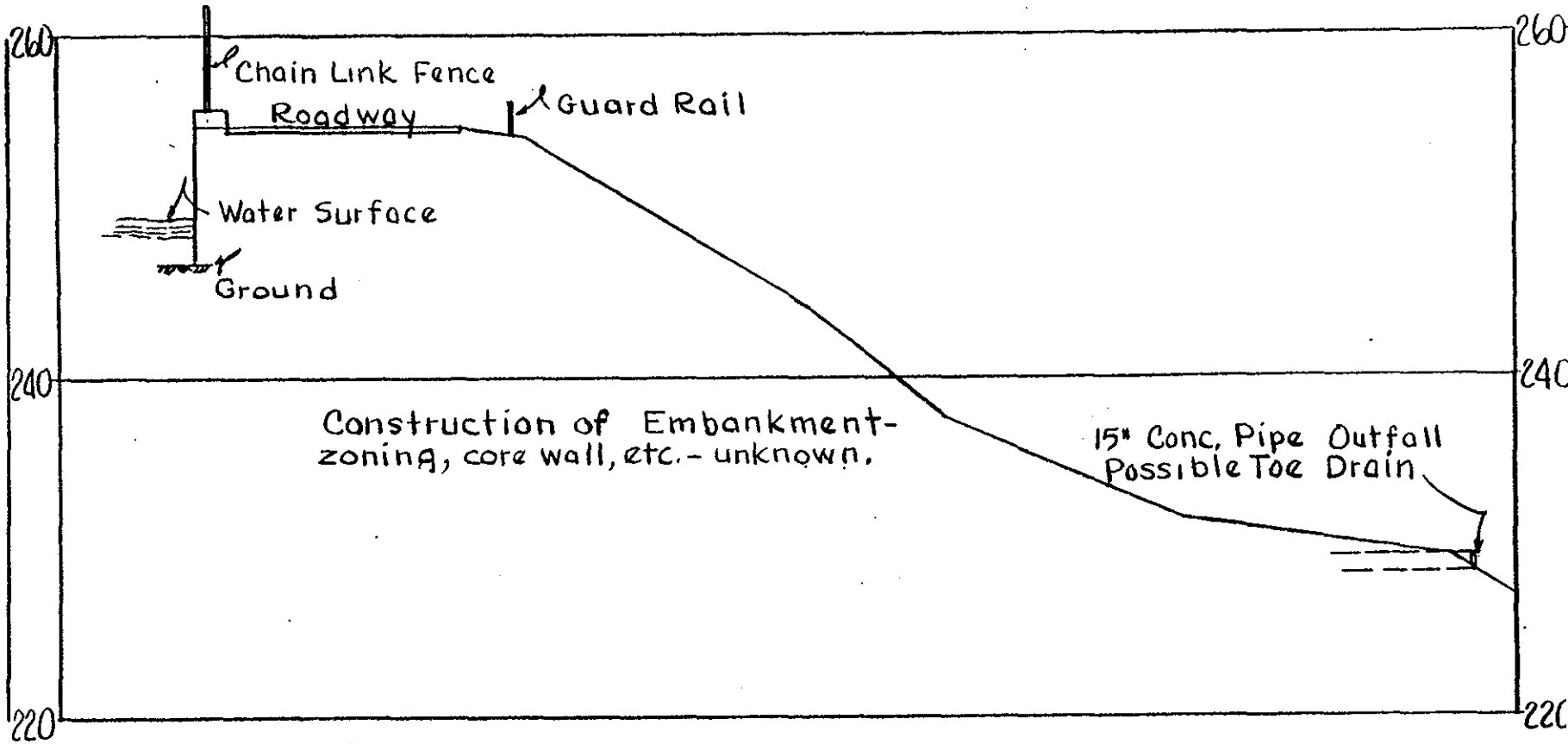
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

MASSABESIC LAKE DAM

COHAS BROOK — NEW HAMPSHIRE

SCALE 1" = 10'

DATE JULY, 1978



SECTION B

TYPICAL EMBANKMENT SECTION

1" = 10'

From original survey by
Whitman & Howard, July 1978.

WHITMAN & HOWARD INC. ENGINEERS AND ARCHITECTS WELLESLEY, MASS.	U.S. ARMY ENGINEER DIV. NEW ENGLAN CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

MASSABESIC LAKE DAM

COHAS BROOK — NEW HAMPSHIRE

SCALE	1" = 10'
DATE	JULY, 1978

WHITMAN & HOWARD, INC.
ENGINEERS AND ARCHITECTS

June 4, 1975

Mr. Robert Beaurivage, P.E.
Manchester Water Works
281 Lincoln Street
Manchester, NH 03101

Dear Bob:

I am enclosing a method for repairing vertical cracks in a concrete gravity dam (or dams) based on the following data and assumptions:

1. The average crack width is 3/8" to 1/2" with one crack being 1" wide.

2. The depth of the cracks are 3" to 4".

3. The cracks are subjected to a maximum back pressure of about 25 feet of water although none are leaking and only a little dampness is present in some.

4. It is assumed the cracks are working shrinkage cracks and they do not impair the adequacy of the structure.

Crack Repair
(Refer to enclosed sketch)

1. Using a saw tooth bit, widen the crack slightly (1/2" minimum width) by cutting a trim, narrow, sharp edged groove to a depth of 2-1/2inches.

2. Clean groove of chipping dust and other foreign material with an air-water jet and dry with an air jet. After cleaning, the groove may be damp but not wet.

3. Fill the rear portion of the groove with an epoxy gel (Sikadur Gel) to a depth of 1 inch.

4. Apply a polyetheylene tape bond breaker to the surface of the cured gel.

5. Prime the sealant slot with Sikaflex Primer and apply a 1-component, polyurethane-base sealant (Sikaflex 1a) to the dimensions shown.

6. Fill remainder of groove with epoxy gel.

7. Tool a 1/8" wide control joint in the gel.

Use the above materials in strict accordance with the manufacturer's directions. All the products mentioned are manufactured by the Sika Chemical Co. of Lyndhurst, New Jersey.

Very truly yours,

WHITMAN & HOWARD, INC.

Anthony Chiaravelotti, P.E.
Head, Structural Department

AC/hmg

enc.

ARTHUR H. ST GERMAIN
President of the Board

GILBERT L. TUSON
Clerk of the Board

CLARENCE E. FERRY, P.E.
Director and
Chief Engineer

FREDERICK H. ELWELL, P.E.
Assistant Director and
Assistant Chief Engineer

MANCHESTER WATER WORKS

281 LINCOLN ST., MANCHESTER, NEW HAMPSHIRE 03103 TEL. 668-3830

March 6, 1975

Mr. George M. McGee, Sr.
Chairman
N. H. Water Resources Board
37 Pleasant St.
Concord, N. H. 03301

Subject: NHWR8 Dam No. 150.06, Manchester, New Hampshire

Dear Mr. McGee:

In reply to your letter of February 14, 1975, we are pleased to furnish you with the following information.

On April 13, 1974, the subject dam was thoroughly inspected by one of our engineers. At this time, pictures of the dam were taken and a report prepared. The report noted (as did yours of July 26, 1974) that some concrete had spalled away from the face of the dam. It did not indicate however any leakage at the right (north) abutment, or for that matter, anywhere else on the face or toe of the dam. This can be substantiated by copy of the enclosed photograph and also by visits on two separate occasions later in the year with contractor representatives. If in fact flowing water appeared at the right side abutment at time of your inspection, we suggest that its origin could only have been from leaking flashboards at the top corner of the dam.

Although plans for repairs to the dam do not include any work on the abutments at this time, you may be assured that if any leakage is found it will be promptly repaired. If any additional information is required at this time, please let me know.

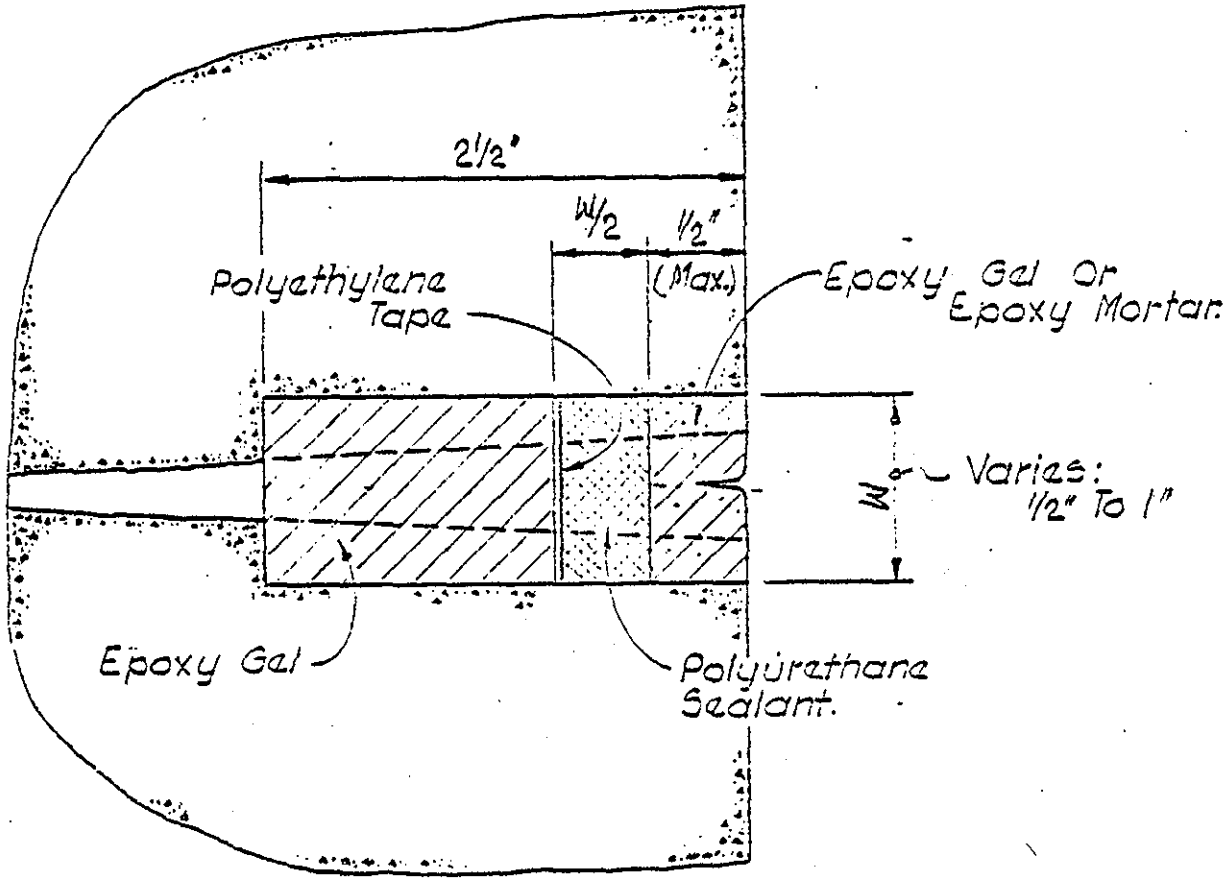
Very truly yours,

David Kittredge

David Kittredge, P. E.
Water Supply Engineer

DK/pp

Enc.



CRACK REPAIR

STATE OF NEW HAMPSHIRE

WATER RESOURCES BOARD

37 Pleasant St.
Concord 03301

February 14, 1975

Manchester Water Works
Lincoln Street
Manchester, NH 03101

CERTIFIED MAIL

Dear Sirs:

On March 15, 1974, an engineer of the New Hampshire Water Resources Board inspected your dam located on Cohas Brook in the town of Manchester.

This dam, # 150.06 in the files of the New Hampshire Water Resources Board, is classified as a menace structure, and as such, must be maintained in a manner so that this structure does not endanger the safety of the public or become a "Dam in Disrepair" (RSA 428:L). Under the statutes, (copies enclosed for your review), this office is responsible for making these inspections periodically and seeking the dam owner's cooperation in making the required repairs.

Since the fall of 1972 the Legislature has attempted to meet its statutory obligations regarding the inspection of dams, and the Board on a priority basis has made inspections in those areas of the state having a history of the least number of inspections over the years. Our priority was to inspect as many dams as possible during times that weather conditions would allow; however, our dam inspector would take immediate action on any structure that was in critical condition. Consequently, we are presently sending out letters notifying owners of dams that certain repairs are required by this Board per the statutes mentioned above. We request that you notify us within 60 days upon receipt of this letter of your intentions as to the completion of these repairs and deficiencies noted on the attached sheet.

We thank you for your cooperation in this regard, and we will be glad to answer any further questions you may have regarding the above.

Very truly yours,

George M. McGee, Sr.
Chairman

gmmg/vak:js
enclosures
cc: Board of Selectmen

Manchester Water Works
Lincoln Street
Manchester, NH 03101

RE: REQUIRED REPAIRS TO DAM #150.06 ON COHAS BROOK, MANCHESTER, N.H.

1. Repair leakage at right abutment (facing downstream).

zd/js

N. H. WATER RESOURCES BOARD
Concord, N. H. 03301

DAM SAFETY INSPECTION REPORT FORM

own: Manchester Dam Number: 150.06

Inspected by: SCD Date: 25 July 1974

Local name of dam or water body:

Owner: Manchester W.W. Address:

Owner was/was not interviewed during inspection.

Drainage Area: _____ sq. mi. Stream: Cohas Brook

Pond Area: _____ Acre, Storage _____ Ac-Ft. Max. Head 20± Ft.

Foundation: Type _____, Seepage present at toe - Yes/No, 4-25

Spillway: Type Ogee Flow, Freeboard over perm. crest: 5'8",

Width 5 sect @ 13', Flashboard height 1'6",

Max. Capacity _____ c.f.s.

Embankment: Type Earth & Stone Cover Road Width 30'±,

Upstream slope 0 to 1; Downstream slope 2 to 1

Abutments: Type Stone, Condition: Good, Fair, Poor

Gates or Pond Drain: Size 30" Capacity _____ Type Cast

Lifting apparatus Handwheel Operational condition Yes

Changes since construction or last inspection: _____

Downstream development: _____

This dam would/would not be a menace if it failed.

Suggested reinspection date: _____

Remarks: Leak @ RT Abt. Surface Cracks on spillway Some erosion of face on spillway

Water Works | PROJECT: Chronology Of Lake Massabesic | PAGE:
MEERING DEPT. | SUBJECT: Changes In Elevation Due To changes In | DATE:
CHESTER, N. H. | DETAIL: M.W.W. Control At Mill Dam | COMPUTED BY:

dte		Top Masonry	Top Flashboards
572	Purchase made of Bottom of Lake And land bordering Mill Pond, Canal And P. Station	(Deed # 14)	
		(called dovetail)	24" Flash
573	Original Masonry Dam Constructed.	147.00	149.00
384	Some time On or After this year the Lake Profile indicates that 30" Flashboards were used	147.00	30" 149.50
122	Top Masonry was capped to a height of 30" above the old Masonry Cap & provided with 3 — Ten foot Spillways 8" deep. The 30" flashboards were a continual source of trouble.	Masonry under Flashboards 148.50	Top Crest of Top Flashbo... 149.5
131	Spillway Capacity increased by removing old concrete substituted for 30" Flashboards in 1922 And constructing new Granite crest on dam 30" above old masonry crest with 5 slots across top to provide for 8" Flashboards across the full 200' length of dam. Old masonry stepped back of dam was lined with and irregular battered concrete face.	148.67	149.5
45	Crest of dam was Altered from the joint under the old masonry cap stone @ Elev. 145.87 from a square crest to a curved crest. The Top of the concrete curved crest is 148.00 with 18" Flashboards. The Bridge Piers & Abuts were raised 1'-0" giving a freeboard of from Elev. 148.00 to bottom of Bridge Stringer Elev. 152.17 = 4.17' Freeboard.	148.00	149.50

chester Water Works
GINEERING
ANCHESTER, N. H.

Mill Dam Spillway Capacity Increase — Summary

Change Dam Spillway + Provide Canal Spillway

The old crest (previous to 1921±) had 30" flashboards and a length of about 90'. The crest was a stone crest of the Merrimack River type. I believe this crest would discharge only 75% of a sharp crested weir.

With the maximum flood of record (1936) the water rose to 0.1' above the bottom of the bridge stringers.

= 151.17 + 0.1 = 151.27 − 147.0 (old crest el.) = 4.27

A depth of 4.27 on a sharp crested weir (use 4' height) would discharge 33.06 per foot @ 90' = 2980 cfs

→ + × .75 = 2230 c.f.s.

Rebuild crest to obtain at least this capacity.

See Sheet 4 — Rebuild with crest at 148.0 with Sloping approach as now 45° + 0.9, curved top. This will have discharge capacity 5 to 10% more than sharp crested weir = type 2 U.S.R.S. book.

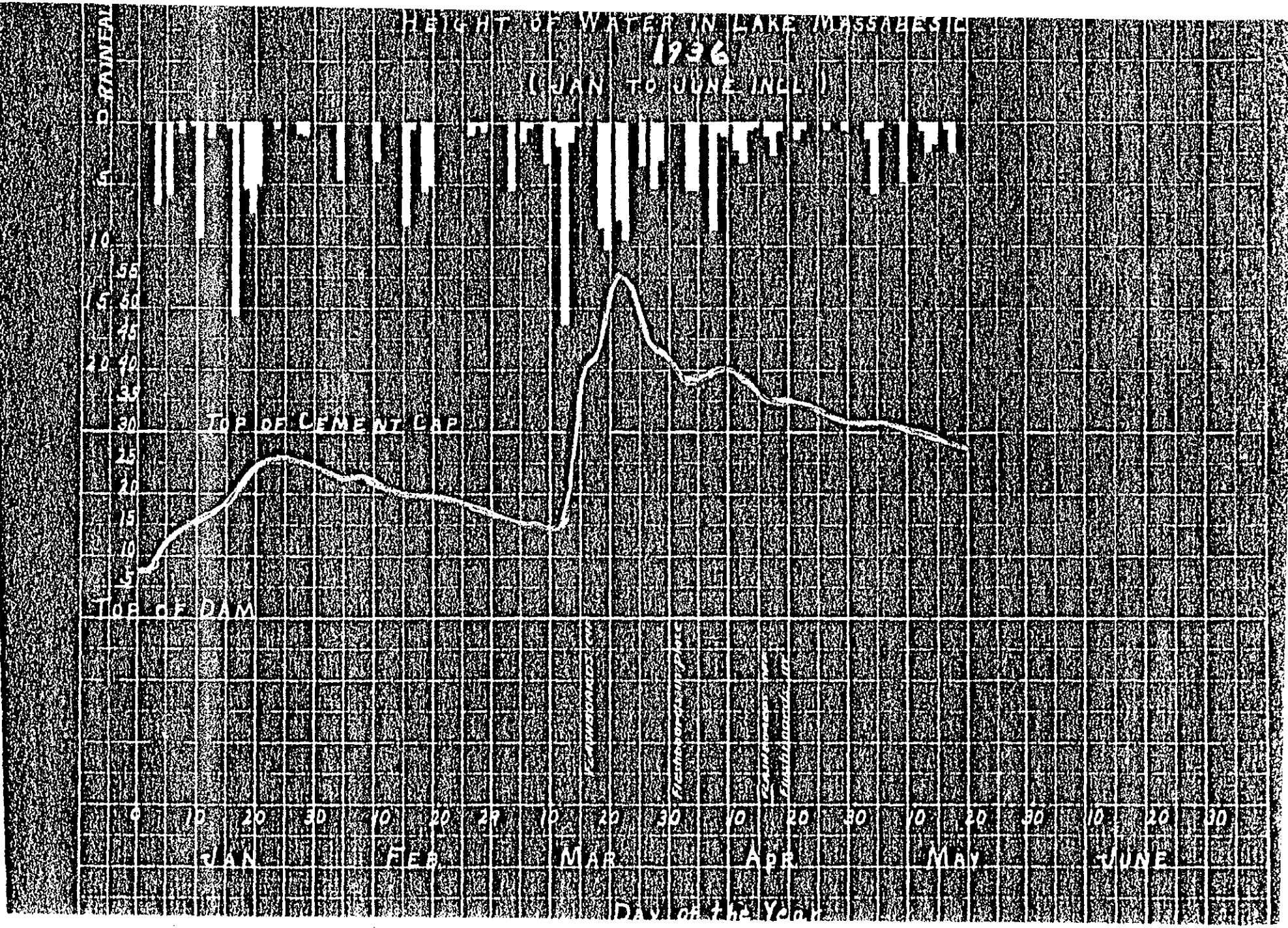
With h = 3.27 Q = 1.05 × 92' × 23.4 = 2260 c.f.s.

In addition get 180± c.f.s. in canal spillway gate & RAISE the Freeboard, or possible Head, by raising bridge & approaches 1.0'

2260
180
2440 cfs / ÷ 2.8 sq mi 57 c.f.s per sq. mi

Previous Max Flood '36 = 31 c.f.s per sq mi
Required full capacity of present spillway.

Note
Absorption capacity of lake 178.0 to 152.0 = 3.6 Billion gallons
149.5 to 152.0 = 2.3 " "


HEIGHT OF WATER IN LAKE MASSABESIC
1936
(JAN TO JUNE INCL.)
FEET ABOVE
TOP OF CEMENT CAP
TOP OF DAM
JAN
FEB
MAR
APR
MAY
JUNE
DAY OF THE YEAR

APPENDIX C

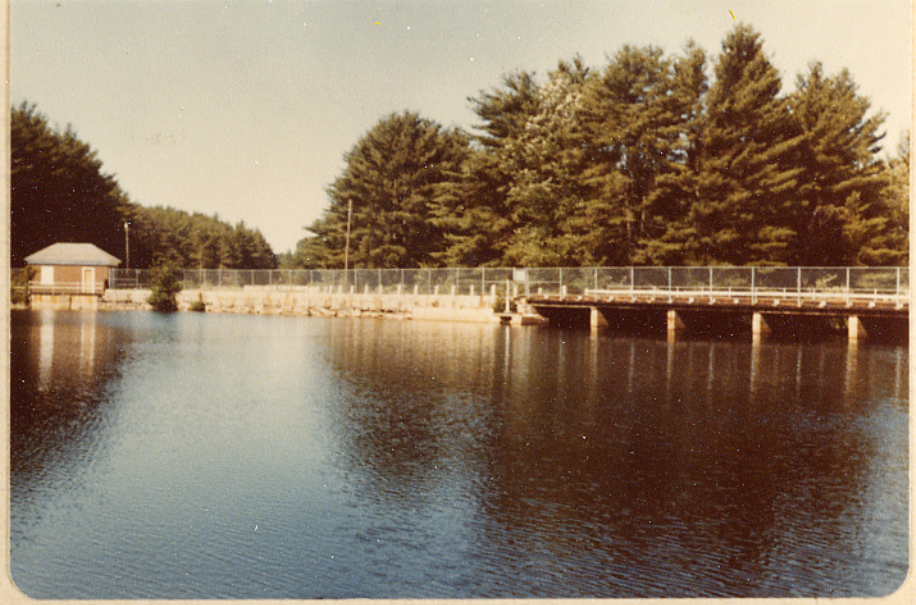
MASSABESIC LAKE DAM

INDEX TO INSPECTION PHOTOGRAPHS

Photo No.	Description
1	View looking southwest across spillway.
2 - 3	Sequence of 2 photos taken clockwise from upstream of northeast abutment, showing gatehouse, southwest embankment section, and southwest end of spillway (2) northeast end of spillway and northeast embankment section (3).
4	View of remnants of timber sheeting on southeast side of canal near southwest end of canal. Entrances to gatehouse visible at top of photo.
5	View of downstream wall of gatehouse at reservoir end of canal and southwest end of dam.
6	View from southwest end of dam along roadway over crest.
7	View looking southwest along canal. Note gatehouse in background.
8	View toward downstream side of embankment on southeast side of canal near gatehouse at southwest end of canal. Bottom of six-foot rule is at surface of standing water next to toe of embankment. Reeds and other marsh plants growing at downstream toe.
9	Looking southwest along guardrails at downstream side of paved road on crest. Misalignment of guardrails appears to be due to auto accident.

Photo No.	Description
10	View of spillway from toe of southwest abutment showing epoxy repairs to vertical cracks. Also note large number of weepholes.
11	Cofferdam from right side. Note submerged walls and top of sluiceway above water. Downstream is to the right.
12	Detail of cofferdam sluiceway. Depth to bottom about 6 ft. Plank partially wrecked.

1



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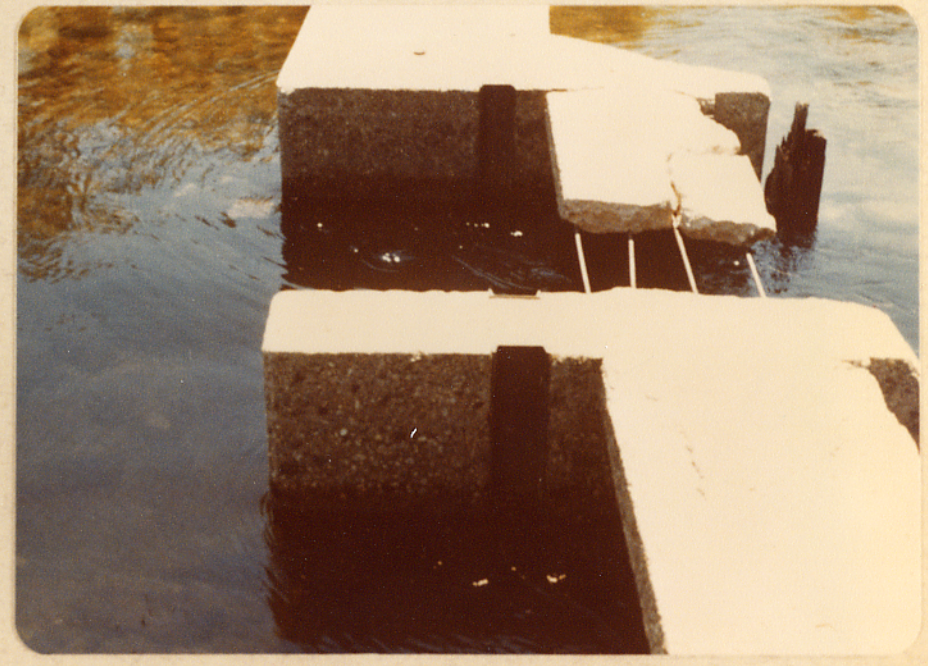


12

APPENDIX D

HYDROLOGIC COMPUTATIONS

WATERSHED MAP

BY T.T.C. DATE July 78 PROJECT Army Corps Engrs SHEET NO. 1 OF 9

CHKD. BY ____ DATE ____ Dam Inspection JOB NO. 8-025

Massabesic Lake (Built 1886, 30 ft high)

I. Hydrology & Hydraulic Data

a) Drainage Area: the total drainage area upstream of the dam is 47 35. miles, which includes drainage areas for Tower Hill Reservoir, Clark Pond, etc.

b) Basin Slope: Along Little Massabesic Brook & Hook Brook

$$\text{Slope} = \frac{640-252}{23000} = 0.01687$$

Along Breston Brook; $\text{Slope} = \frac{500-252}{25000} = 0.0082$

Conclusion: Though the slope along Little Massabesic Brook & Hook Brook is little steeper than flat channel, due to there being lots of wet lands along the channels, and Tower Hill Reservoir and several small ponds located upstream of Massabesic Lake, which are all serviced as detention area, the drainage basin condition can be considered as Flat Area.

c) Water Surface Area: Neglecting all other reservoirs, the water area for Massabesic Lake = 2634 Acres At El. 250.43 and is increased at a rate of about 100 - 150 Acres per foot increase in elevation. For the purpose of estimation, use 100 acres increase per foot, increased up to 3000 acres. (Since top of dam elevation is 254.52)

d) Storage Capacity:

U.S.G.S. Elv.	Area (Acres)	Storage (A.F.)
254.52	3000 Estimate	10,034
250.43	2634	1310
249.43	2605	1,265
248.43	2575	1,223
244.43	2394	993
239.43	1338	

Spillway Crest Elev. = 243.33

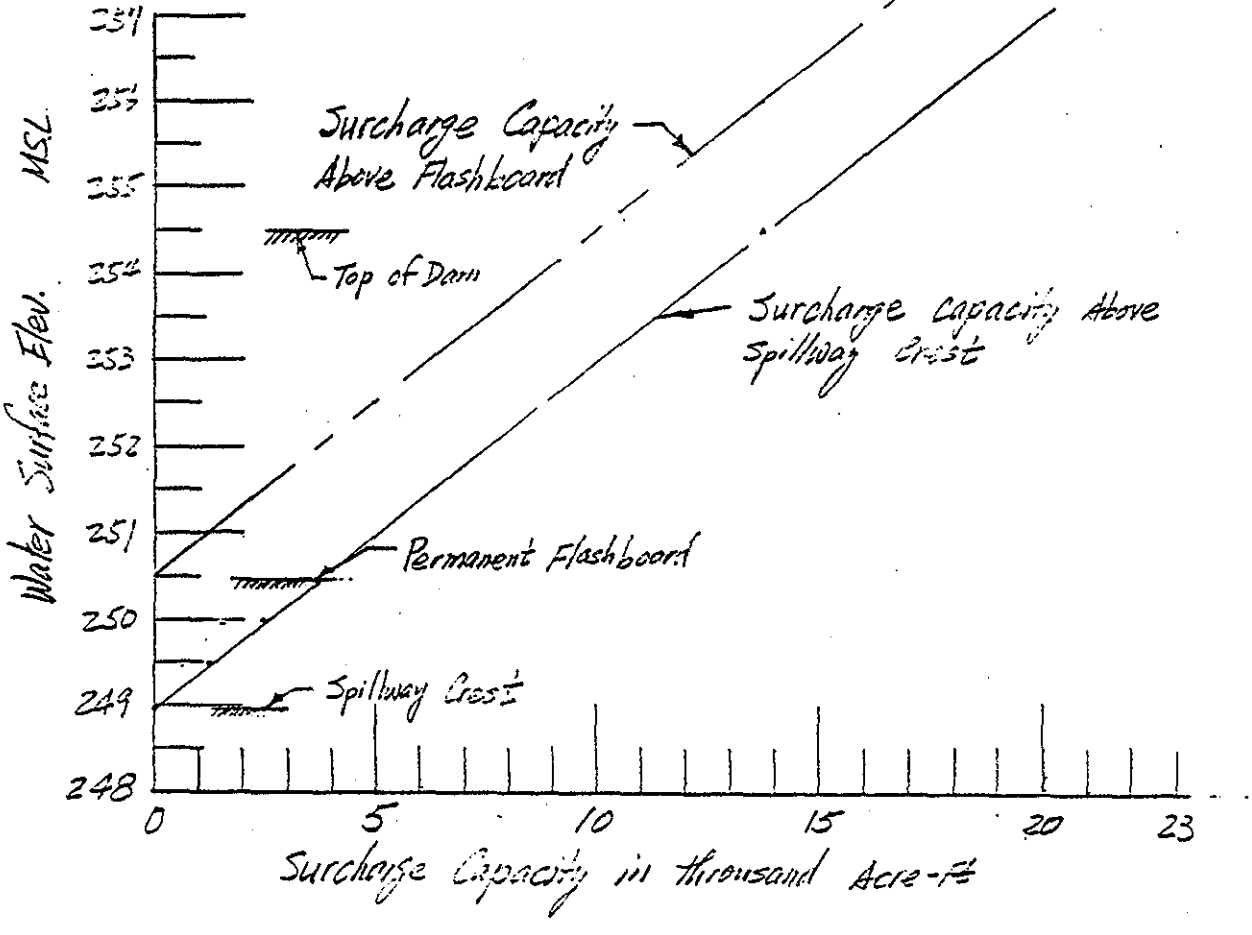
the total storage of the top .5 ft (from Top of Dam down) is about 39548 Acre-Ft. Since there was no information concerning the rest storage capacity, it is estimated as follows.

At El. 239.43 Area = 1838 Acres
" 224.43 Area = 0.0 Acres
Average = 919 Acres

Estimate storage volume for the lower portion of the Lake = 919 x 15 x .75 = 10,322 Acre-Ft.

Therefore total storage = 43,220 Acre-Ft, it can be considered as intermediate storage reservoir but very close to large reservoir category.

e) Surcharge Capacity Curve



BY T.T.C. DATE [illegible] PROJECT [illegible] SHEET NO. 3 OF 9
CHKD. BY ______ DATE ______ Dam Safety Inspect. - Massachusetts JOB NO. [illegible]

f) Spillway Capacity.

Spillway Max. Capacity (Neglecting Wave effect)
$= 3.6 \times 100 \times (254.5 - 249)^{3/2} = 4644$ cfs

Spillway normal capacity (With 2.4 ft wave effect)
$= 3.6 \times 100 \times (5.5 - 2.4)^{3/2} = 1965$ cfs.

Spillway Max. capacity with Permanent Flashboard
$= 3.6 \times 100 (5.5 - 1.5)^{3/2} = 2880$ cfs

There are two outlet pipes, both have 3'φ with a capacity of 180 cfs, but one of the gates has not been operated for long time.

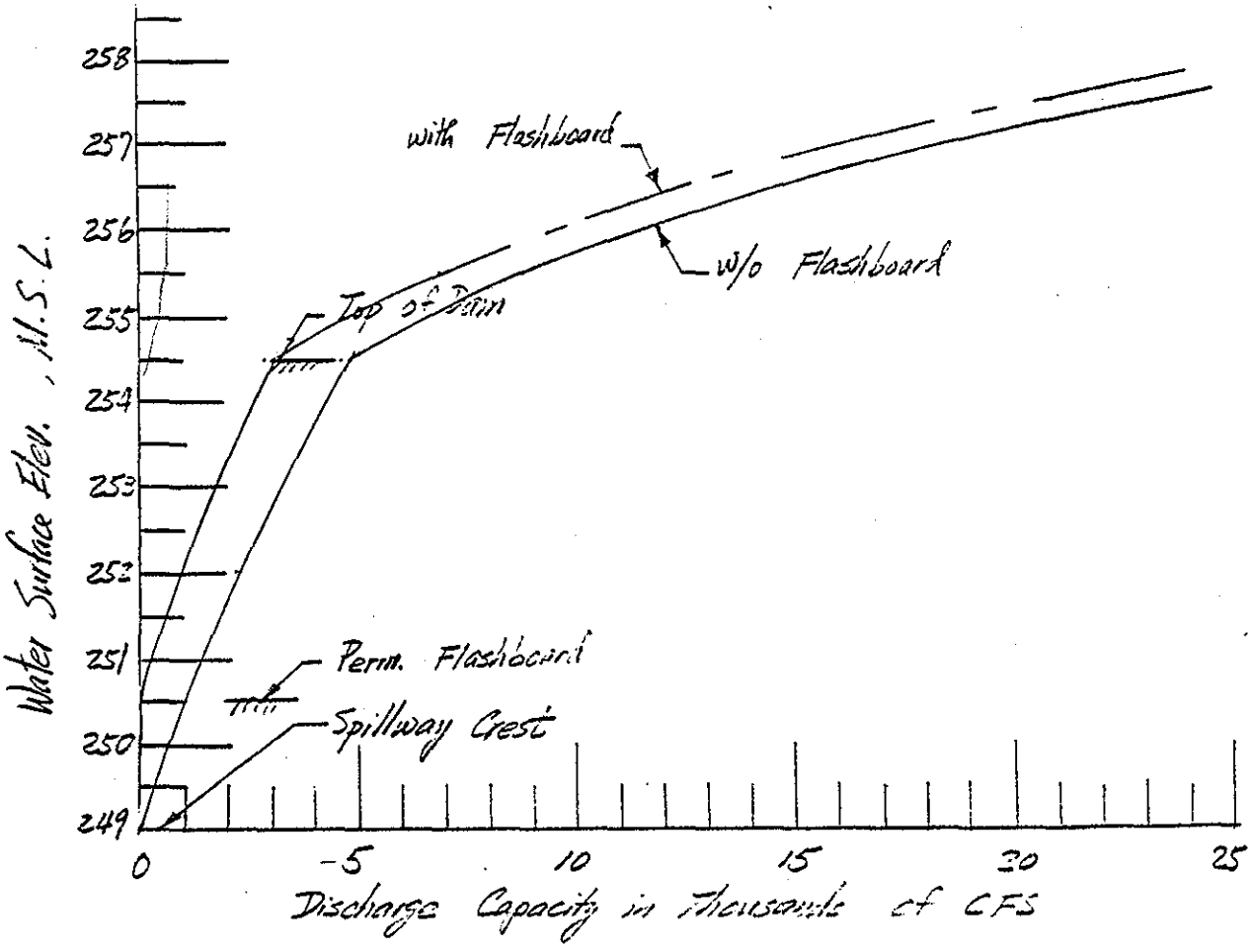
g) Discharge Curve with consideration of the dam length as additional broadcrest weir, length = 1000', C = 2.7. (Assume overtopping will not cause dam failure, but this is not to suggest that an earth dam can be overtopped. The first rule for earth embankment design is that this shall not be overtopped.)

For Water Surface At Top of Dam $Q_D = 4644 + 180 = 4824$ cfs
For Water Surface At 1 ft above Dam $Q_D = 180 + 3.6 \times 100 \times 6.5^{3/2} + 2.7 \times 1000 = 8846$ cfs
For Water surface At 4 ft above Dam
$Q_D = 180 + 3.6 \times 100 \times 9.5^{3/2} + 2.7 \times 1000 (4)^{3/2}$
$= 180 + 10541 + 21600 = 32321$ cfs

For Water 3 ft overtopping $Q_D = 180 + 3.6 \times 100 \times 8.5^{3/2} + 2.7 \times 1000 (3)^{3/2}$
$= 180 + 8921 + 14030 = 23131$

If the permanent flashboard will stay, then the capacity will reduce correspondingly
Water At Top of Dam $Q_D = 2880 + 180 = 3060$ cfs
1 ft above Top of Dam $Q_D = 4025 + 180 + 2700 = 6905$ cfs
4 ft above Top of Dam $Q_D = 8146 + 180 + 21600 = 29926$ cfs
3 ft above Top of Dam $Q_D = 20877$ cfs

WHITMAN & HOWARD, INC.
45 WILLIAM STREET, WELLESLEY, MASS.
Engineers and Architects



h.) Estimated Peak Probable Maximum Flood inflow = 505 cfs/sq. mi.

i.) Neglecting Tower Hill Reservoir and other small Pond storage effect: Peak inflow = 505 x 47 = 23,735 cfs
Spillway maximum Capacity = 4644/23735 = 20% of Peak inflow.

ii.) Considering Tower Hill Reservoir storage effect.
Due to the adequate spillway capacity of Tower Hill Reservoir, the effect of storage does not affect the peak inflow rate, since when considering a small Watershed area, the runoff rate per unit watershed area becomes higher, so is the inflow. Therefore use peak PMF = 23740 cfs

BY T.I.C. DATE 8/6/12 PROJECT Army Corps Engineers SHEET NO. 5 OF 9

CHKD. BY DATE Dam Safety Inspection - Massabesic JOB NO. 8-085

ii) Estimating Effect of Surcharge Storage on PMF peak.

(i) Assume Perm. Flashboard Will be remove, for QPI = 23740 cfs.

$H_1 = 257.1 - 249 = 8.1$ From Discharge rating curve

$STOR1 = 8.1 \times 3000 \times 1.563 \times 10^{-3} \times 12/47$

$= 9.70$ inch

$QP2 = QPI\left(1 - \frac{9.70}{19}\right) = 11624$ cfs

$H_2 = 256.0 - 249 = 7.0$ ft

$STOR2 = 7.0 \times 3000 \times 0.001563 \times 12/47 = 8.37$ inch

$STOR_{Ave} = \frac{9.7 + 8.37}{2} = 9.04$ inch

$QP3 = QPI\left(1 - \frac{9.04}{19}\right) = 12,448$ cfs

$H_3 = 256.3 - 249 = 7.3$ ft

$STOR3 = 7.3 \times 3000 \times 0.001563 \times 12/47$

$= 9.4$ in

$QP4 = QPI\left(1 - \frac{9.4}{19}\right) = 11,939$ cfs

$H_4 = 256.10 - 249 = 7.1$

$STOR4 = 7.1 \times 3000 \times 0.001563 \times 12/47$

$= 8.45$ in

$STOR_{Ave} = \frac{8.45 + 9.4}{2} = 8.92$ inch

$QP5 = QPI\left(1 - \frac{8.92}{19}\right) = 12591$ cfs say 12,600 cfs

$H = 256.2 - 249 = 7.2$ ft Overtopping 1.7 ft

(ii) If Perm. Flashboard Will not be removed

$H_1 = 257.8 - 249 = 8.8$ ft

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STOR1 = 8.8 x 12 x 3000 x 1.533 / 47000 = 10.54 inch

$QP2 = 23740 \left(1 - \frac{10.54}{19}\right) = 10575$ cfs

$H_2 = (256.2 - 249) = 7.2$ ft

$STOR2 = 7.2 \times 12 \times 3 \times 1.563 / 47 = 8.62$ in

$STOR_{Ave} = \frac{8.62 + 10.54}{2} = 9.58$ in

$QP3 = 23740 \left(1 - \frac{9.58}{19}\right) = 11,770$ cfs

$H_3 = 256.35 - 249 = 7.35$ ft ≤ 7.2 ft

Use $H_3 = 7.4$ ft

So it is about 3.2 to 3.5 ft overlay the earth embankment.

The existing earth embankment and the section of roadway, which have (above) same elevation and have all been considered as broadcrest weir if overtopped, are not in very good condition, especially, the main dam. The design and construction data for the dam could not be found; the fills of the dam therefore are unknown. The reservoir is intermediate in size, but has a large water surface area; if the dam fails, with a city of Manchester near the downstream, the hazard would be very high.

Therefore, increasing the spillway capacity, is necessary.

j) Improvement:

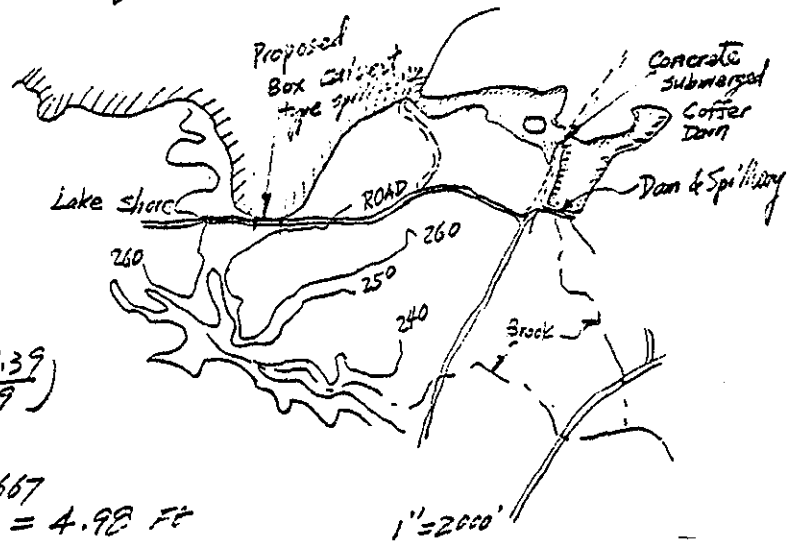
There are several possible ways to increase the spillway capacity.

1) By raising the dam, which does not seems economical, because the height has to be raised by over 10 ft., and the length may be too long. Detail survey of the Lake shore

would be necessary to determine the total volume needed for raising the dam and determination of the cost would be needed. Flashboard should be converted to failure type, at higher head, so to provide additional capacity of flood caused by hurricane, waves, with their effects, resulted.

2) increase existing spillway length at Dam
try 300' Ogee Spillway

$$H = \left(\frac{23740}{300 \times 3.6}\right)^{0.667}$$
$$= 7.85 \text{ Ft}$$



$$STOR1 = 7.85 \times 3000 \times 12 \times 1.563 / 47000$$
$$= 9.39 \text{ inch}$$

$$QP2 = 23735 \times \left(1 - \frac{9.39}{19}\right)$$
$$= 12000 \text{ cfs}$$

$$H_2 = \left(\frac{12000}{300 \times 3.6}\right)^{0.6667} = 4.98 \text{ Ft}$$

$$STOR2 = \frac{4.98 \times 9.39}{7.85} = 5.96 \text{ inch}$$

$$STOR_{AVG} = \frac{5.96 + 9.39}{2} = 7.675 \text{ inch}$$

$$QP3 = 23735\left(1 - \frac{7.675}{19}\right) = 14,147 \text{ cfs}$$

$$H = \left(\frac{14147}{300 \times 3.6}\right)^{0.6667} = 5.56 \text{ Ft} \quad < 5.59 \text{ Ft gross freeboard}$$

3) Wave height.
Direct water surface straight length toward dam
$= 1750 \text{ ft} = 0.083 \text{ stat. mile} = F$
Using 80 mile/hr $= V$

$$h_w = 0.17\sqrt{V \cdot F} + 2.5 - \sqrt[4]{F}$$
$$= 0.44 + 2.5 - .54 = 2.40 \text{ Ft} \quad (\text{max.})$$

therefore actual length of spillway would have to be

much longer or a masonry wall for wave protection should be constructed, if wave effect is considered

4) Convert Lake Shore Road with box culverts as emergency spillway. The box culverts may have invert Elevation of 248.5 with 2 Ft flashboard

Using 1.0 Ft For wave protection, so max. water level would at Elev. 253.5 (Addition wave protection could be added by stone wall)

Spillway Crest El. 248.93

H = 4.57 Ft

Spillway Capacity = $3.6 \times 100 \times (4.57)^{3/2}$

= 3517 cfs Say 3500 cfs.

With surcharge effect, the MPF = 15,000 cfs

Emergency Spillway Capacity = 11,500 cfs

Use Broad. Weir C = 3.0 H = 253.5 - 248.5 = 5.0

$Q = CBH^{3/2}$ $B = \frac{11500}{3.0 \times 11.18} = 342$ Ft in length

h) Conclusion:

1. Hydraulically, the spillway length is too short. It only can discharge about 20% of the estimated PMF peak inflow.
2. There are several alternatives to increase the capacity of the spillway; by raising the dam earth embankment section, by constructing additional spillway, or by the combination. But detail analysis should be carried through, before any design and construction changes are made.
3. There is an exist masonry cofferdam about 300 Ft upstream of the existing dam. The cofferdam is still in fair condition. Therefore, it serves as a safety factor; so, an emergency alarming system could

be installed, if anything happened to the dam, using the cofferdam to protect a complete loss of the reservoir may save much damage.

4. The present spillway already has cracked. Due to the high water level, the actual condition of the spillway, especially upstream, can not be inspected, therefore, block the cofferdam and drain the small ponding area between the cofferdam and the dam to have a detailed inspection for the planning of spillway capacity expansion.

5. The actual length of the spillway should be determined by detailed flood routing method, since the cost-benefit analysis should be determined. We all like to see a super-safe construction, but economically, it may not be a good design.

6. The upstream face stone wall (riprap) is in fair to poor condition; maintenance of the riprap stone wall should be done when draining the small pond between cofferdam & main dam.


WATERSHED AREA
MASSABESIC LAKE DAM
SCALE 1:62,500
U.S.G.S. QUARD. SHEETS-
(MANCHESTER, N.H. & SUNCOOK, N.H)
Hall Mtn
Clay Pond
Hinman Pond
Dubes Pond
Rowes Corner
Moose
Maple
Meadow
Brook
Candia Hill Sch
Candia Four Co
Kinnicum Pond
Candia (PO)
MERRIMACK CO
ROCKINGHAM CO
Tower Hill
Tower Hill Pond
Clark Pond
Murray
Mill
Brook
Hooke Crossing
Auburn Station
AUBURN
Little Massabesic Lake
Mt Pisgah
Mt Miner
CHESTE
Severance
Massabesic
Massabesic Lake
Battery Pt
Auburn
Spruce Lake
Rocky Pt
Currier Point
Spruce Swamp
ROCKINGHAM CO
HILLSBOROUGH CO
Pumping Sta
Deer Neck
Preston
Brook
Long Meadow Ch
Calef Pond
Fletcher Island
Browns Island
Long Meadow Cem
Birch Island
Grape Islands
CHES

APPENDIX E

INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

INVENTORY OF DAMS IN THE UNITED STATES

STATE	IDENTITY NUMBER	DIVISION	STATE	COUNTY	CONGR DIST.	STATE	COUNTY	CONGR DIST.	NAME	LATITUDE (NORTH)	LONGITUDE (WEST)	REPORT DATE DAY	MO	YR
NH	103	NED	NH	011	01				MASSABESIC LAKE DAM	4257.8	7125.7	15	AUG	78

POPULAR NAME	NAME OF IMPOUNDMENT
	MASSABESIC LAKE

REGION	BASIN	RIVER OR STREAM	NEAREST DOWNSTREAM CITY–TOWN–VILLAGE	DIST FROM DAM (MI.)	POPULATION
01	05	COHAS BROOK	MANCHESTER	1	87800

TYPE OF DAM	YEAR COMPLETED	PURPOSES	STRUCTURAL HEIGHT (FT.)	HYDRAULIC HEIGHT (FT.)	IMPOUNDING CAPACITIES MAXIMUM (ACRE–FT.)	IMPOUNDING CAPACITIES NORMAL (ACRE–FT.)	DIST	OWN	FED R	PRV/FED	SCS A	VER/DATE
CTRAPG	1873	S	28	27	56000	44500	NED	N	N	N	N	04AUG78

REMARKS

D/S HAS	SPILLWAY CREST LENGTH	SPILLWAY TYPE	SPILLWAY WIDTH (FT.)	MAXIMUM DISCHARGE (FT.)	VOLUME OF DAM (CY)	POWER CAPACITY INSTALLED (MW)	POWER CAPACITY PROPOSED (MW)	NAVIGATION LOCKS NO.	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)
1	500	C	100	2260	7500	.4										

OWNER	ENGINEERING BY	CONSTRUCTION BY
MANCHESTER WATER WORKS		

REGULATORY AGENCY			
DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE
NH WATER RES BD	NH WATER RES BD	NH WATER RES BD	NH WATER RES BD

INSPECTION BY	INSPECTION DATE DAY	MO	YR	AUTHORITY FOR INSPECTION
WHITMAN + HOWARD	12	JUN	78	PL 92-367

REMARKS